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(54) Power saving arrangement for a radiotelephone

(57) The radiotelephone of the invention includes a receiver front end (12) for amplifying a received signal and converting the amplified received signal into a first intermediate-frequency signal, an intermediate-frequency demodulator (13) for converting the first intermediate-frequency signal into a second intermediate-frequency signal to demodulate it and for producing an RSSi signal indicative of strength of the received input signal and a power limitation portion (17 or 18) for limiting power supply to the receiver front end (12) to save consumption power of the receiver when the RSSi signal exceeds a predetermined reference voltage.

FIG. 2

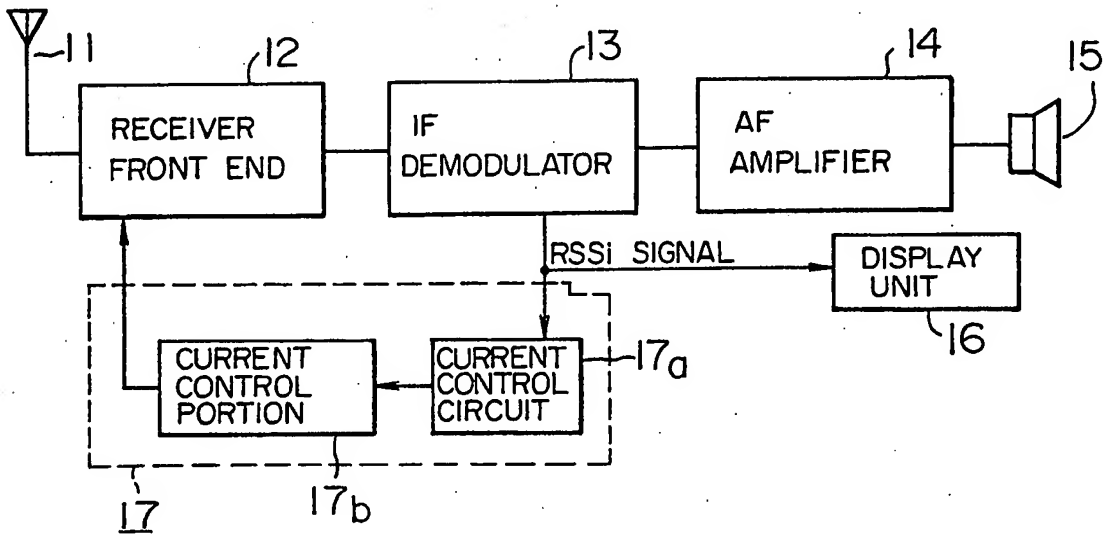

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FIG. 1
PRIOR ART

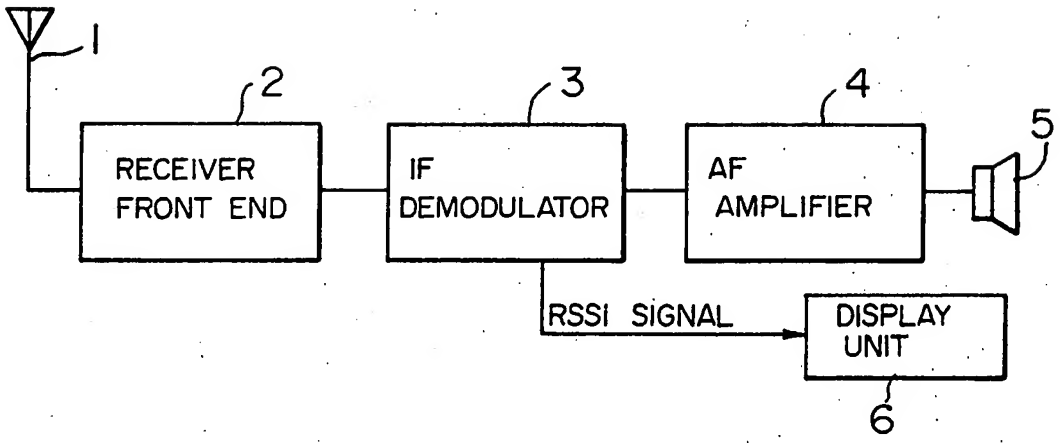


FIG. 2

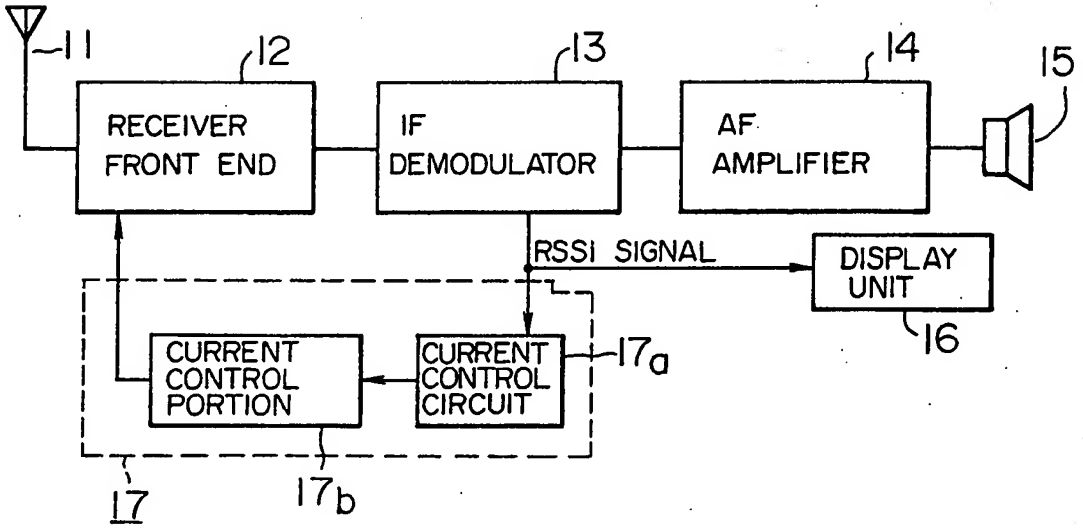


FIG. 3

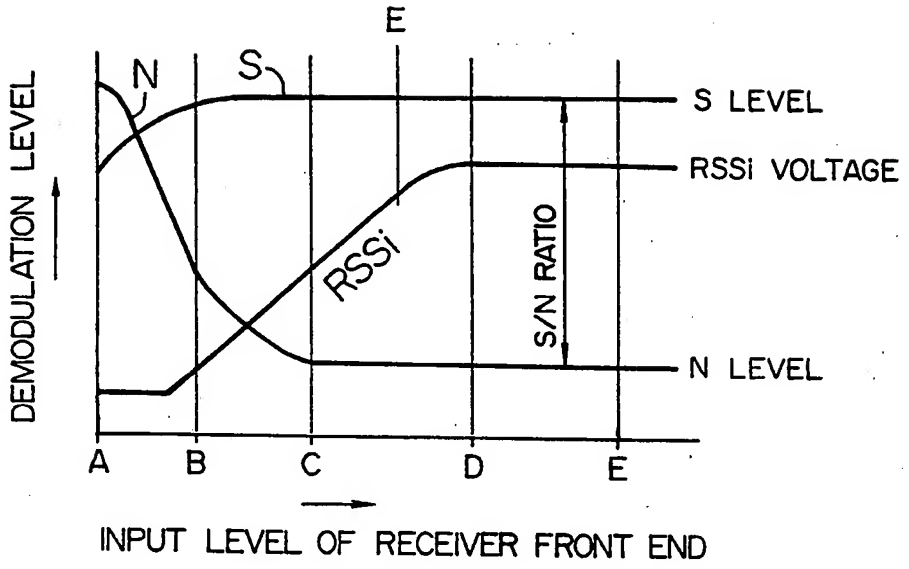
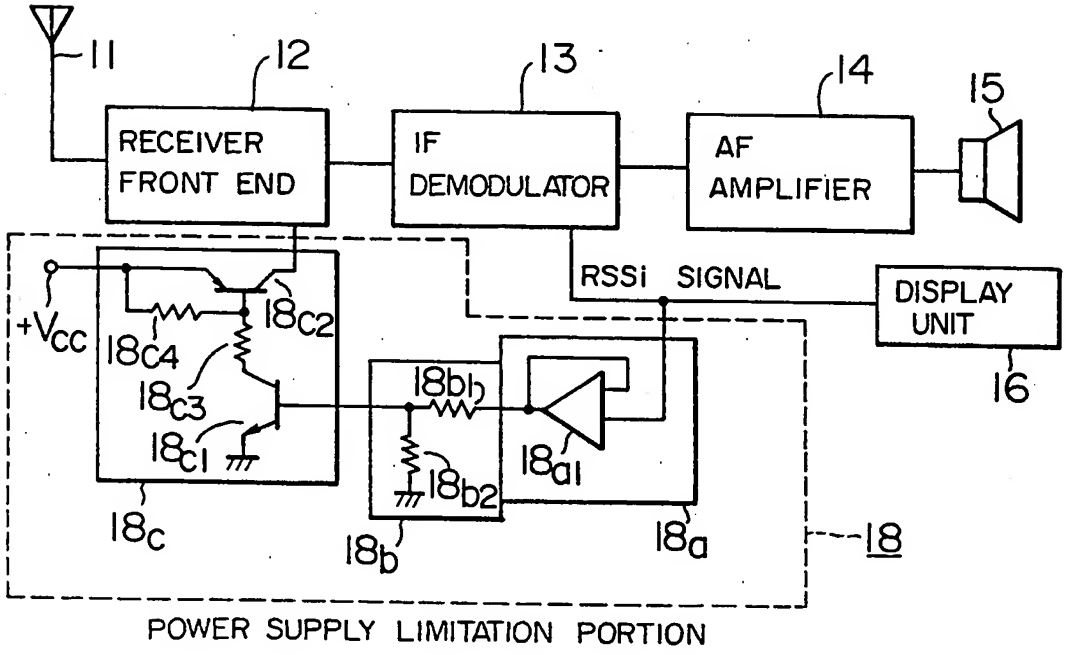

E
N
S
S LEVEL
RSSi VOLTAGE
DEMODULATION LEVEL
RSSi
S/N RATIO
N LEVEL
A
B
C
D
E
INPUT LEVEL OF RECEIVER FRONT END

FIG. 4


11
12
13
14
15
RECEIVER FRONT END
IF DEMODULATOR
AF AMPLIFIER
RSSi SIGNAL
DISPLAY UNIT
16
+Vcc
18c2
18c4
18c3
18c1
18c
18b1
18b2
18b
18a1
18a
18
POWER SUPPLY LIMITATION PORTION

POWER SAVING APPARATUS OF A RADIOTELEPHONE.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a power saving apparatus of a radiotelephone for use in a portable radiotelephone, a small radio receiver and the like.

DESCRIPTION OF THE RELATED ART

Heretofore, in order to save power consumption of a radio receiver, there is a radio receiver of the type in which a radio wave is received at a short timing in a waiting time for receiving the radio wave. Fig. 1 shows a functional configuration of a conventional radio receiver.

In Fig. 1, numeral 1 denotes an antenna for receiving an radio wave transmitted from a base station not shown, numeral 2 denotes a receiver front end for amplifying a high-frequency received signal of the radio wave received by the antenna 1 and mixing the amplified received signal with a local oscillation signal to produce a first intermediate-frequency signal.

Numeral 3 denotes an IF (intermediate-frequency) demodulator for converting the first intermediate-frequency signal produced from the receiver front end 2 into a second intermediate-frequency signal and

demodulating the second intermediate-frequency signal to produce an audio signal and for producing an RSSi (received signal strength indication) signal indicating strength of a received signal, numeral 4 denotes an AF (audio frequency) amplifier for amplifying the audio signal produced from the IF demodulator 3 to drive a loudspeaker 5, and numeral 6 denotes a display unit for displaying a level of the RSSi signal indicative of the strength of the received signal produced from the IF demodulator 3.

Operation of the conventional radio receiver is now described. In Fig. 1, the electric wave transmitted from the base station is received by the antenna 1 at a short timing and the high-frequency received signal is amplified by the receiver front end 2.

The receiver front end 2 mixes the amplified high-frequency received signal with the local oscillation signal to produce the first intermediate-frequency signal, which is supplied to the IF demodulator 3 in which the first intermediate-frequency signal is converted into the second intermediate-frequency signal and the second intermediate-frequency signal is demodulated to produce the audio signal.

The audio signal is amplified by the AF amplifier 4 and the loudspeaker 5 is driven by the amplified audio signal.

At the same time, the RSSi signal indicative of the strength of the received signal is supplied from

the IF demodulator 3 to the display unit 6 which displays a level of the RSSi signal, so that a user can be informed of the strength of the received signal.

In the conventional radio receiver used in a radiotelephone, however, since the waiting time is longer as compared with the communicating time, more particularly, the waiting time is about ten times as long as the communicating time, power saving in the waiting time is very important. Further, it is necessary to start receiving the radio wave in a short time by triggers in order to maintain the function of the receiver for a long time with a small battery.

On the other hand, in a portable radiotelephone set for a mobile telephone, there is a tendency that a distance between base stations is gradually shortened in order to attain the portable radiotelephone set having a small size and a light weight. Accordingly, the tendency that a mobile station communicates within an area of the strong electric field of the base station is increased.

In such a strong electric field, a current in the receiver front end 2 can be limited to suppress the consumption of the battery, while the current limitation is not considered heretofore.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the problems in the prior art and to provide a radiotelephone capable of limiting a current flowing in a receiver front end and other components in accordance with the strength of a received signal and reducing consumption power of the whole apparatus to save electricity.

Further, it is another object of the present invention to provide a radiotelephone capable of using the apparatus for a long time by power saving of the whole apparatus and miniaturizing a battery mounted in the apparatus to lighten the whole apparatus.

In order to achieve the above objects, the present invention comprises a receiver front end for amplifying a received signal and converting it into a first intermediate-frequency signal, intermediate-frequency demodulating means for converting the first intermediate-frequency signal into a second intermediate-frequency signal and demodulating the converted second intermediate-frequency signal and for producing an RSSi signal indicative of strength of the received input signal, audio frequency amplifying means for amplifying the demodulated signal output from the intermediate-frequency demodulating means in the telephone conversation to drive a loudspeaker, and electric power control means for limiting a current in the receiver front end when the RSSi signal exceeds a predetermined

reference level to save consumption power of the receiver.

Since the present invention comprises a receiver front end for amplifying a received signal and converting it into a first intermediate-frequency signal, intermediate-frequency demodulating means for converting the first intermediate-frequency signal into a second intermediate-frequency signal and demodulating the converted second intermediate-frequency signal and for producing an RSSi signal indicative of strength of the received input signal, audio frequency amplifying means for amplifying the demodulated signal output from the intermediate-frequency demodulating means in the telephone conversation to drive a loudspeaker, and electric power control means for limiting a current in the receiver front end when the RSSi signal exceeds a predetermined reference level to save consumption power of the receiver, the current flowing in the receiver front end can be limited in accordance with the strength of the received signal to reduce the consumption power of the whole apparatus to save electricity so that the apparatus can be used for a long time and a battery mounted in the apparatus can be miniaturized to lighten the whole apparatus.

The present invention can be applied widely to a radiotelephone of a single zone and a multiple zone type including a base station and a mobile station, and particularly the present invention is suitable for a

portable telephone set of a mobile telephone of cellular type and sub-telephone set of a wireless telephone in which a battery saving is an important subject.

In the present invention, since a normal mode in which power saving is not made and a power saving mode in which power saving is made are switched in accordance with an input level of the receiver, consumption power in a waiting time which occupies a large percentage of an operating time of the receiver can be reduced greatly.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing a configuration of a conventional radiotelephone;

Fig. 2 is a block diagram showing a functional configuration of a radio receiver to which a power saving apparatus of a radiotelephone according to the present invention is applied;

Fig. 3 shows relation of a received input signal of the radio receiver of Fig. 2 and an S/N ratio, and the received input signal and an RSSi signal; and

Fig. 4 is a block diagram showing a function configuration of another radiotelephone according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiments of the present invention are now described with reference to the drawings. Fig. 2 shows

a functional configuration of an embodiment of the present invention.

In Fig. 2, numeral 11 denotes an antenna and numeral 12 denotes a receiver front end including a high-frequency amplifier (not shown) for amplifying a high-frequency signal received by the antenna 11, a first frequency converter (not shown) for mixing the amplified high-frequency received signal with a local oscillation signal to produce a first intermediate-frequency signal, and a first IF amplifier (not shown) for amplifying the first intermediate-frequency signal.

Numeral 13 denotes an IF demodulator including a second frequency converter (not shown) for mixing the first intermediate-frequency signal amplified by the first IF amplifier in the receiver front end with a local oscillation signal and converting the mixed signal into a second intermediate-frequency signal, a second IF amplifier (not shown) for amplifying the second intermediate-frequency signal, a signal demodulator (not shown) for demodulating the second intermediate-frequency signal amplified by the second IF amplifier to produce an audio signal, and an RSSi signal portion (not shown) for detecting strength of the received signal form the second intermediate-frequency signal amplified by the second IF amplifier to produce an RSSi signal indicative of the strength of the received signal.

Numeral 14 denotes an AF amplifier which operates in the telephone conversation to amplify the

audio signal produced by the IF demodulator 13 to drive a loudspeaker 15 and includes a squelch circuit (not shown) and loudspeaker change-over circuit (not shown).

Numeral 16 denotes a display unit which is supplied with the RSSi signal produced by the RSSi signal portion of the IF demodulator 13 and displays the strength of the received signal on the basis of the RSSi signal.

Numeral 17 denotes a current control circuit (power control means) including a central control unit (hereinafter referred to as a CPU) 17a which takes in the RSSi signal produced by the RSSi signal portion of the IF demodulator 13 continuously or at regular intervals to compare a level of the RSSi signal with a predetermined reference level at intervals of a fixed time in a comparator 17a and controls a current control portion 17b when the RSSi signal exceeds the predetermined level.

Further, the current control portion 17b supplies a control signal to the receiver front end 12 in response to an output of the CPU 17a to control the receiver front end 12 so that a current in the receiver front end 12 is reduced to a reference level or less (current control means).

Operation of the embodiment is now described. In the embodiment, when the antenna 11 of the radio receiver receives an radio wave transmitted from a base station, the received signal is amplified by the high-

frequency amplifier in the receiver front end 12 and the amplified received signal is mixed with the local oscillation signal in the frequency converter to produce the first intermediate-frequency signal.

The first intermediate-frequency signal is amplified by the first IF amplifier. The amplified signal is supplied to the second frequency converter of the IF demodulator 13 to be mixed with the local oscillation signal in the second frequency converter to be converted into the second intermediate-frequency signal.

The second intermediate-frequency signal is amplified by the second IF amplifier of the IF demodulator 13 and is demodulated by the demodulator to be supplied to the AF amplifier 14 as the audio signal. The audio signal is amplified by the AF amplifier 14 and is output from the loudspeaker 15.

Further, when a level of the input signal to the receiver front end 12 is reduced to a predetermined level or less, a noise appears at the output terminal of the AF amplifier 14. Accordingly, the squelch circuit operates to switch the input to the loudspeaker 15 by the loudspeaker change-over circuit.

On the other hand, in the IF demodulator 13, part of the second intermediate-frequency signal amplified by the second IF amplifier is supplied to the RSSi signal portion so that the RSSi signal indicative of the strength of the received signal is supplied from the RSSi signal portion to the display unit 16, which

displays the strength of the received signal in the digital value.

At the same time, the RSSi signal produced from the RSSi signal portion is supplied to the CPU 17a (comparison means) of the current control circuit 17 and the CPU 17a compares the level of the RSSi signal with the predetermined reference level.

When it is confirmed that the level of the RSSi signal exceeds the reference level as a result of the comparison in the CPU 17a, the CPU 17a supplies an output signal to the current control portion 17b and the current control portion 17b controls the receiver front end 12 so that the mode of the receiver front end 12 is switched from a normal mode in which the reception sensitivity is normally set in the maximum to a power saving mode to limit the current in the receiver front end and reduce the gain thereof so that the level of the RSSi signal is reduced to the predetermined level or less. Thus, the consumption of the battery of the radio receiver is controlled to perform the power saving.

Fig. 3 shows an S/N characteristic of the radio receiver and a characteristic of the RSSi signal versus the received input signal.

The AF output of the receiver at point A includes noise only because the received input signal is null as shown in Fig. 3. Point B represents a threshold point of the receiver. The S/N ratio and the input level at the threshold point of point B are expressed by

the following equations, respectively:

$$S/N(th) = \beta^2 \cdot (B/2b) \cdot Cf$$

$$P(th) = Cf \cdot K \cdot T \cdot B \cdot F$$

where β denotes the modulation index, B the bandwidth of the radio receiver, b the bandwidth of the audio frequency, Cf the power ratio of the carrier versus noise at the threshold point, K Boltsmann's constant, T the absolute temperature, and F the noise figure of the receiver.

Therefore, the S/N ratio is calculated to 16 dB, when β = 2 rad, B = 8 kHz, b = 3 kHz and Cf = 8, and the input level at the threshold point to -7 dBμ when T = 298°K, F = 4 and K = 1.38×10^{-23} J/°K.

The input level and the S/N ratio increase proportionally from point B to point C.

The input level is observed at +22 dBμ and the S/N ratio at 45 dB at point C, and those values beyond point C tend to be constant corresponding to the received input level.

Further, the RSSi signal indicative of the strength of the received input signal is increased in proportional to the received input signal until being saturated in a fixed value wherein the input level can not be determined over the vicinity of the point D where P=60 dBμ. Considering some margins, the reference point for the comparison in CPU 17a is set at point E where P

gets 45 dBμ, and CPU 17a controls the current control portion 17b to reduce the gain of the receiver front end 12 when the input signal exceeds point E.

The current limitation is not made during P is less than 45 dBμ. However, the reference point can be freely changed by a program of the CPU 17a selected from the point E and D and any lower point than the point D.

Further, the comparison procedure in the CPU 17a may have such a hysteresis characteristic for stabilization in a mode change-over that the current limitation is started when the RSSi signal exceeds the point D in Fig. 3 and is stopped when the RSSi signal is reduced to the point E.

SECOND EMBODIMENT

Fig. 4 shows a configuration of a second embodiment, in which numerals 1 to 16 designate the similar components of Fig. 2. This embodiment is different in that a power supply limitation portion 18 is configured by discrete components.

Numeral 18 denotes the power supply limitation portion which takes in the RSSi signal produced by the RSSi signal portion of the IF demodulator 13 continuously or at regular intervals to compare a voltage level of the RSSi signal with a predetermined reference voltage (not shown) at intervals of a fixed time in a comparison portion 18a and the comparison portion 18a produces an information signal when the RSSi signal exceeds the

predetermined voltage.

Further, the power supply limitation portion 18 adjusts an output level of the information signal produced by the comparison portion 18a in a level adjustment portion 18b to supply it to a current control portion 18c, which limits a supply power to the receiver front end 12 on the basis of the level-adjusted information signal and reduces the reception gain thereof to perform the power saving.

The comparison portion 18a is mainly composed of a comparator 18a1 and the level adjustment portion 18b divides the output voltage of the comparison portion 18a by resistors 18b1 and 18b2 to perform the level adjustment. The level-adjusted signal is applied from a junction between the resistors 18b1 and 18b2 to a base of a transistor 18c1 of the current control portion 18c.

The current control portion 18c is mainly composed of transistors 18c1 and 18c2. An emitter of the transistor 18c1 is connected to ground and a collector of the transistor 18c1 is connected through a resistor 18c3 to a base of the transistor 18c2.

A voltage +Vcc is applied to the collector of the transistor 18c1 through a resistor 18c4 and the resistor 18c3 and is also applied to the base of the transistor 18c2 through the resistor 18c4.

The voltage +Vcc is directly applied to an emitter of the transistor 18c2 and a collector thereof is connected to the receiver front end 12.

More particularly, the transistor 18c1 produces an output signal in accordance with the output of the level adjustment portion 18b to vary an internal impedance of the transistor 18c2 in accordance with the output signal so that the supply power to the receiver front end 12 is limited to reduce the gain of the receiver front end 12 so that the power saving is performed.

Operation of the second embodiment is now described with reference to Fig. 4. Operation of the second embodiment that the antenna 11 of the radio receiver receives an radio wave transmitted from the base station, the RSSi signal is produced and the display unit 16 displays the strength of the received input signal is the same as that of the embodiment of Fig. 2.

Operation of the power supply control portion 18 is now described.

The RSSi signal produced by the RSSi signal portion is supplied to the comparator 18a1 of the comparison portion of the power supply control portion 18 and the comparator 18a1 compares the RSSi signal with a predetermined reference voltage.

When it is confirmed that the RSSi signal exceeds the reference voltage as a result of the comparison by the comparator 18a1, the comparator 18a1 supplies an information signal to the level adjustment portion 18b and the signal is divided to a predetermined level by the resistors 18b1 and 18b2 in the level

adjustment portion 18b to be applied to the transistor 18c1 of the current control portion 18c.

Thus, the transistor 18c1 turned on to drive the transistor 18c2, so that the reception gain of the receiver front end 12 is decreased to reduce the current and hence saves the battery of the radio receiver.

CLAIMS:

1. A radiotelephone comprising a receiver front end for amplifying a received signal and converting the amplified received signal into a first intermediate-frequency signal, intermediate-frequency demodulation means for converting the first intermediate-frequency signal into a second intermediate-frequency signal to demodulate it and for producing an RSSi signal indicative of strength of the received input signal, audio frequency amplifying means for amplifying the demodulated output signal of said intermediate-frequency demodulator in telephone conversation to drive a loudspeaker, and power control means for limiting consumption power of said receiver front end to switch from a normal mode to a power saving mode when said RSSi signal exceeds a predetermined reference level.

2. A radiotelephone according to Claim 1, wherein said power control means includes comparison means for comparing a level of said RSSi signal with a reference level to produce an output signal when said RSSi signal exceeds said reference level, and current control means for reducing the consumption power of said front end in response to the output signal of said comparison means.

3. A radiotelephone according to Claim 2, wherein the comparison of the said comparison means is performed by a CPU.

4. A radiotelephone according to Claim 2, wherein said current control means includes at least one

transistor circuit.

5. A radiotelephone according to Claim 1, comprising display means for displaying the level of said RSSi signal.

6. A radiotelephone according to Claim 5, wherein said display means also displays other conditions of the radiotelephone.

7. A radiotelephone substantially as hereinbefore described with reference to and as shown in the Figures 2 and 3 or Figure 4 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9119982.8

Relevant Technical fields

(i) UK Cl (Edition K) H3G (GSE, GSX) H4L (LECX, LERX)

(ii) Int Cl (Edition 5) H04B 1/16

Search Examiner

N W HALL

Databases (see over)

(i) UK Patent Office

(ii) WPI ON LINE

Date of Search

17 FEBRUARY 1992

Documents considered relevant following a search in respect of claims 1-7

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X, P	GB 2233846 A (ORBITEL) Whole document	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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